

## TITLE OF THE INVENTION

### CODING DEVICE, CODING METHOD AND STORAGE MEDIUM

## FIELD OF THE INVENTION

5       The present invention relates to a coding device and coding method for encoding image data, and a storage medium thereof.

## BACKGROUND OF THE INVENTION

10       Recently, due to the spread of personal computers and mobile terminals, communication of digital data (data communication) via Internet has come into general practice. One of digital data distributed in data communication is an motion image. Since the motion image has large quantity  
15 of data, it is encoded with static images and associated voices (frames) as units before it is sent, thus reducing the data amount of the motion image.

As a method of encoding motion image data like this, there has been the method of encoding image data in which  
20 image coded data is provided with a function of enhancing precision of the decoded image (scalability) with the progress of decoding of image coded data obtained by encoding image data in motion image data.

For the conventional method of encoding image data,  
25 however, there have been cases where for some code length of image coded data having a scalability function, this

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image coded data could not be decoded within a time period over which the one-frame image is played back.

#### SUMMARY OF THE INVENTION

5           The present invention has been made in the light of the above described problems, and is to provide a coding device and coding method for fixing the code length of image coded data in accordance with the code length conforming to required criteria, and a storage medium thereof.

10           Particularly, the object of the present invention is to provide a technology for generating coded data, which can cope with various kinds of decoding/playback speeds/times, or a technology for decoding coded data in accordance with various kinds of decoding/playback  
15 speeds/times, in a state in which hierarchical coding can be performed.

For achieving the objects of the present invention, a coding device of the present invention has a configuration described below, for example. That is,

20           a coding device for encoding image data, comprising:  
transforming means for performing discrete wavelet transformation on inputted image data, thereby generating transformation factors of a plurality of frequency sub-bands;

25           coding means for entropy-coding each of the above described sub-bands; and

generating means for monitoring the amount of coded data of a predetermined sub-band in the above described sub-bands, and if the predetermined sub-band exceeds a predetermined code length, removing coded data included in  
 5 an area where the sub-band exceeds the predetermined code length, and if the predetermined sub-band does not reach the above described predetermined code length, adding dummy data to the coded data of the above described sub-band, thereby generating fixed length coded data of the above  
 10 described predetermined code length.

Also, another coding device has a configuration described below. That is,

a coding device for encoding image data of each frame constituting an motion image, comprising:

15 transforming means for performing discrete wavelet transformation on inputted image data, thereby generating transformation factors of a plurality of frequency sub-bands;

coding means for entropy-coding each of the above  
 20 described sub-bands; and

generating means for monitoring the amount of coded data of a predetermined sub-band in the above described sub-bands, and if the predetermined sub-band exceeds a predetermined code length, removing coded data included in  
 25 an area where the sub-band exceeds the predetermined code length, and if the predetermined sub-band does not reach the above described predetermined code length, adding dummy

data to the coded data of the above described sub-band,  
thereby generating fixed length coded data of the above  
described code length.

Other objectives and advantages besides those  
5 discussed above shall be apparent to those skilled in the  
art from the description of a preferred embodiment of the  
invention which follows. In the description, reference is  
made to accompanying drawings, which form a part thereof,  
and which illustrate an example of the invention. Such  
10 example, however, is not exhaustive of the various  
embodiments of the invention, and therefore reference is  
made to the claims which follow the description for  
determining the scope of the invention.

15 BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a block diagram showing a configuration of  
a coding device in a first embodiment of the present  
invention;

FIG. 1B is a block diagram showing a configuration of  
20 a frame data coding unit 101;

FIG. 1C is a block diagram showing a configuration of  
an image data coding unit 106 in FIG. 1B;

FIG. 1D is a block diagram showing a configuration of  
a voice data coding unit 105 in FIG. 1B;

25 FIG. 2 illustrates a configuration of frame data;

FIG. 3 illustrates separation of frame data;

FIG. 4 shows a configuration of frame coded data;

FIG. 5 illustrates discrete wavelet transformation;

FIG. 18 is a flowchart of generation of image coded data in the fourth embodiment of the present invention;

FIGS. 19A and 19B illustrate sub-band division by discrete wavelet transformation in fifth to seventh, ninth  
5 and tenth embodiments;

FIG. 20 shows correspondence of each frequency component to a quantizing step in the fifth to seventh, ninth and tenth embodiments of the present invention;

FIG. 21 shows code block division of each sub-band in  
10 the fifth to tenth embodiments;

FIG. 22 shows division of each code block into bit planes in the fifth to tenth embodiments of the present invention;

FIG. 23 shows division of each code block into bit  
15 planes in the fifth to tenth embodiments of the present invention;

FIG. 24 is a block diagram showing a configuration of a frame decoding device in the fifth to tenth embodiments of the present invention;

FIG. 25 is a flowchart of processing of generating  
20 decoded image data and displaying the decoded image in the fifth embodiment of the present invention;

FIG. 26 is a block diagram showing a configuration of a normal decoding unit 2402 in the fifth embodiment of the  
25 present invention;

FIG. 27 shows length fixation of unit data in the sixth embodiment of the present invention;

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FIG. 28A shows use of LL and HL1 sub-bands for quick decoding in the sixth embodiment of the present invention;

FIG. 28B shows use of LL, HL1, LH1, HH1 and HL2 sub-bands for quick decoding in the sixth embodiment of the present invention;

FIG. 29 shows length fixation of unit data in the seventh embodiment of the present invention;

FIG. 30 shows use of a group of sub-bands of level 0 and level 1 for quick decoding in the seventh embodiment of the present invention;

FIG. 31 illustrates a layer arrangement in image coded data of the tenth embodiment of the present invention;

FIG. 32 shows length fixation of unit data in the eighth embodiment of the present invention;

FIG. 33 illustrates layers in the ninth and tenth embodiments of the present invention;

FIG. 34 illustrates a layer arrangement in image coded data of the ninth embodiment of the present invention;

FIG. 35 illustrates hierarchical display in which image quality is gradually improved while an image size is unchanged;

FIG. 36A is a block diagram showing a configuration of a frame data coding unit A3607 in the fifth embodiment;

FIG. 36B is a block diagram showing a configuration of an image data coding unit A3601 in the fifth embodiment;

FIG. 36C is a block diagram showing a configuration of a frame coding device in the fifth embodiment;

09851559-051001

FIG. 37 is a block diagram showing a configuration of an image data coding unit B4202 in the sixth embodiment;

FIG. 38 is a block diagram showing a configuration of an image data coding unit C4302 in the seventh embodiment;

5 FIG. 39 is a block diagram showing a configuration of an image data coding unit D4402 in the eighth embodiment;

FIG. 40 is a block diagram showing a configuration of an image data coding unit E4502 in the ninth embodiment;

10 FIG. 41 is a block diagram showing a configuration of an image data coding unit F4602 in the ninth embodiment;

FIG. 42A is a block diagram showing a configuration of a frame coding device in the sixth embodiment;

FIG. 42B is a block diagram showing a configuration of a frame data coding unit B4201 in the sixth embodiment;

15 FIG. 43A is a block diagram showing a configuration of a frame coding device in the seventh embodiment;

FIG. 43B is a block diagram showing a configuration of a frame data coding unit C4301 in the seventh embodiment;

20 FIG. 44A is a block diagram showing a configuration of a frame coding device in the eighth embodiment;

FIG. 44B is a block diagram showing a configuration of a frame data coding unit D4401 in the eighth embodiment;

FIG. 45A is a block diagram showing a configuration of a frame coding device in the ninth embodiment;

25 FIG. 45B is a block diagram showing a configuration of a frame data coding unit E4501 in the ninth embodiment;



FIG. 46A is a block diagram showing a configuration of a frame coding device in the tenth embodiment;

FIG. 46B is a block diagram showing a configuration of a frame data coding unit F4601 in the sixth embodiment;

5 FIG. 47 illustrates a coding pass selected in the layer arrangement in the ninth embodiment;

FIG. 48 is a flowchart showing processing of the layer arrangement in the ninth embodiment;

FIG. 49 is a block diagram showing a configuration of  
10 a frame decoding device in the sixth embodiment;

FIG. 50 is a block diagram showing a configuration of a frame decoding device in the seventh embodiment;

FIG. 51 is a block diagram showing a configuration of a frame decoding device in the eighth embodiment;

15 FIG. 52 is a block diagram showing a configuration of a frame decoding device in the ninth embodiment; and

FIG. 53 is a block diagram showing a configuration of a frame decoding device in the tenth embodiment.

## 20 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

The present invention will be described below in accordance with preferred embodiments, referring to the accompanying drawings.

[First Embodiment]

25 Assume, in this embodiment, that an motion image to be encoded has a plurality of frames. The frame refers to one static image in the motion image and a voice rolled forth

09851559-051001

for a time period over which the static image is projected (display time). Thus, data of the frame (frame data) is comprised of data of one static image (image data) and data of voice (voice data). Also, the encoding of frame data to generate frame coded data means the encoding of each of image data and voice data to generate image coded data and voice coded data. Furthermore, reduction of sound quality is generally more noticeable than reduction of image quality.

10        Thus, for the encoding of voice data in the present invention, a reversible coding system to prevent any information loss due to coding is used.

Also, when one frame coded data is inputted in a device for decoding frame coded data (decoding device), the frame coded data is separated into image coded data and voice coded data. At this time, if the code length of image coded data varies for each frame coded data, the coding device retrieves the start of voice coded data in each frame and recognizes the code length of the image coded data before performing separation. This requires much time. Thus, quicker separation of image coded data and voice coded data is desired. This is achieved by fixation of the code length of image coded data (length fixation of image coded data) in all frame data.

25        Also, there may be cases where due to length fixation of image coded data, image coded data to be decoded is made to constitute a part of the inputted image coded data, and

decoding of the part of image coded data (partial decoding) is performed.

In spite of partial decoding, however, the outline of the image obtained by decoding of the entire image coded data (full decoding) (full decoded image) needs to be displayed. This is achieved by performing recurrently discrete wavelet transformation on the low frequency sub-band of image data to generate image coded data during coding, performing partial decoding of the image coded data in succession in the order of from the lowest frequency sub-band to the highest frequency sub-band during decoding, and displaying the same.

A coding device and coding method for generating image coded data satisfying the above described conditions, and generating frame coded data from the image coded data and voice coded data will be presented below,

FIG. 1A is a block diagram showing a configuration of a coding device in this embodiment.

In this figure, reference numeral 101 denotes a frame data coding unit, and reference numeral 102 denotes a designated image coded data code length inputting unit.

The frame data coding unit 101 encodes frame data inputted in the coding device in this embodiment. Also, the code length of image coded data to be subjected to length fixation is inputted in the designated image coded data code length inputting unit 102. Furthermore this code length that is inputted shall be a code length such that the outline

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of the image (predetermined by the user) included in frame coded data can be displayed within a time period over which the decoding device plays back each frame data even for partial decoding.

5        A configuration of the frame data coding unit 101 is shown in FIG. 1B, a configuration of an image data coding unit 106 in FIG. 1B is shown in FIG. 1C, and a configuration of a voice data coding unit 105 in FIG. 1B is shown in FIG. 1D. Also, a flowchart of processing of generation of frame coded data frame data coding unit 101 described later is shown in FIG. 14, and explanation thereof will be given using this figure.

10        First, frame data comprised of image data and voice data, as shown in FIG. 2, is inputted from a frame data inputting unit 103, and is outputted to a frame data separation unit 104 (Step S1401). For this frame data inputting unit 103, for example, image pickup equipment such as a digital video camera and a digital still camera, an image pickup device such as a CCD, an interface of the network line or the like is used. Also, the frame data inputting unit 103 may be a recording medium such as a RAM, a ROM, a hard disk, a CD-ROM or the like.

20        Furthermore, a plurality of frame data in an motion image that is to be encoded shall be inputted each by each in the frame data inputting unit 103. Also, processing after the frame data inputting unit 103 shall be performed independently for each frame data.

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Frame data inputted in the frame data separation unit 104 is separated into voice data and image data, as shown in FIG. 3 (Step S1402). And, the voice data and the image data are inputted in the voice data coding unit 105 and the image data coding unit 106, respectively.

The image data inputted in the image data coding unit 106 is encoded by processing described later to become image coded data (Step S1403). And, the image coded data is inputted in a frame coded data generation unit 107.

10 The voice data inputted in the voice data coding unit 105 is encoded by a reversible coding system in each unit described later to become voice coded data (Step S1404). And, the voice coded data is inputted in the frame coded data generation unit 107.

15 When the voice coded data and the image coded data are inputted in the frame coded data generation unit 107, a header is generated (Step S1405). Furthermore, the size of image data inputted in an image inputting unit 109, information on types and the like showing whether the image data is a binary image or a multi-valued image, the length of the image coded data, the length of the voice coded data, a character string showing a coding device sending the data, a send date and so on are written in the header. If the image coded data includes an adjustment bit, the code length of the adjustment bit is also written. And, as shown in FIG. 4, frame coded data is generated from the header, the voice coded data and the image coded data (Step S1406).

In a frame coded data sending unit 108, the inputted frame coded data is sent to the outside (Step S1407). For this frame coded data sending unit 108, an interface such as a public line, a wireless line, a LAN or the like may  
5 be used.

A flowchart of processing of coding of image data in the image data coding unit 106 in Step S1403 is shown in FIG. 15, and the explanation thereof will be given below, using this figure.

10 Image data to be encoded in a frame in this embodiment shall be 8-bit monochrome image data. However, the data can also be applied when it is a monochrome image in which each pixel is expressed by the number of bits other than 8 bits like 4 bits, 10 bits and 12 bits, or multi-valued  
15 image data of color in which each color component (RGB/Lab/YCrCb) in each pixel is expressed by 8 bits. Also, the data can be applied when it is multi-valued information showing a state and the like of each pixel constituting the image, for example a multi-valued index value showing the  
20 color of each pixel. For application to those, each kind of multi-valued information may be defined as monochrome image data described later.

First, pixel data constituting image data to be encoded is inputted in raster scan order from the image data  
25 inputting unit 109, and is outputted to a discrete wavelet transformation unit 110. For this image data inputting unit 109, for example, image pickup equipment such as a

scanner and a digital camera, an image pickup device such as a CCD, an interface of a network line or the like is used. Also, the image data inputting unit 109 may be a recording medium such as a RAM, a ROM, a hard disk, a CD-ROM or the like.

The discrete wavelet transformation unit 110 performs discrete wavelet transformation using data (reference pixel data) of plurality of pixels (reference pixels) in image data  $x(n)$  of one static image inputted from the image data inputting unit 109 (Step S1501).

Image data after discrete wavelet transformation (discrete wavelet transformation factor) is as follows:

$$r(n) = \text{floor}\{(x(2n)+x(2n+1))/2\};$$

$$d(n) = x(2n+2)-x(2n+3)+\text{floor}\{(-r(n)+r(n+2)+2)/4\},$$

where  $r(n)$  and  $d(n)$  are discrete wavelet transformation factor sequences, and  $r(n)$  and  $d(n)$  refer to low and high frequency sub-bands, respectively. Also, in the above equations,  $\text{floor}\{X\}$  represents a maximum value that does not exceed  $X$ . A view depicting this discrete wavelet transformation in schematic form is shown in FIG. 5.

Although this transformation equation is for one-dimensional data, this transformation is applied in lateral direction and then in vertical direction to perform two-dimensional transformation, thereby enabling division into four sub-bands of LL, HL, LH and HH as shown in FIG. 6A. Here, L represents a low frequency sub-band and H

represents a high frequency sub-band. Then, in a similar way, the LL sub-band is divided into four sub-bands (FIG. 6B), and the LL sub-band of them is further divided into four sub-bands (FIG. 6C). Totally, ten sub-bands are  
5 prepared. The ten sub-bands are referred to as HH1, HL1, ..., respectively, as shown in FIG. 6C. Here, the number in the name of each sub-band refers to a level of each sub-band. That is, sub-bands of level 1 are HL1, HH1 and LH1, and sub-bands of level 2 are HL2, HH2 and LH2.  
10 Furthermore, the LL sub-band is a sub-band of level 0. No subscript is assigned to the LL sub-band because there is only one LL sub-band. Also, the decoded image obtained by decoding sub-bands of level 0 to level n is called a decoded image of level n. For the decoded image, the higher its  
15 level, the higher its resolution. That is, for image data subjected to discrete wavelet transformation, the outline of the original image can be displayed by partial decoding.

The transformation factors of ten sub-bands are stored in a buffer 111 on a temporary basis, and are outputted to  
20 a factor quantization unit 112 in the order of LL, HL1, LH1, HH1, HL2, LH2, HH2, HL3, LH3 and HH3, namely in the order of from the lowest level sub-band to the highest level sub-band.

The factor quantization unit 112 quantizes the  
25 transformation factor of each sub-band outputted from the buffer 111 by a quantizing step determined for each frequency component, and outputs a value after quantization



(factor quantization value) to an entropy coding unit 113 (Step S1502). When the factor value is X, and the value of the quantizing step for the frequency component to which this factor belongs is q, the factor value after

5 quantization Q(X) is determined by the following equation.

$$Q(X) = \text{floor}\{(X/q)+0.5\}$$

Correspondence of each frequency component to a quantizing step in this embodiment is shown in FIG. 7. As shown in this figure, a larger quantizing step is given to  
10 a sub-band of higher level. Furthermore, the quantizing step for each sub-band is previously stored in a memory such as a RAM and ROM (not shown). And, all the transformation factors in one sub-band are quantized, followed by outputting those factor quantization values to the entropy  
15 coding unit 113.

The entropy coding unit 113 entropy-encodes the inputted factor quantization value by arithmetic coding to generate an entropy coded value (Step S1503). The entropy coded value is outputted to an image coded data generation  
20 unit A114. The entropy coded value inputted in the image coded data generation unit A114 is arranged in the unit of sub-bands as shown in FIG. 8, and quasi image coded data is generated (Step S1504).

Also, the generated quasi image coded data is subjected  
25 to length fixation to form image coded data as described below.

If the code length of quasi image coded data is larger than the code length designated by the designated image coded data code length inputting unit 102 (Step S1505), in order for the data to have a designated code length, entropy  
 5 coded values are deleted in the unit of sub-bands in the order of resolution level with the highest level the first, or in the same level in the order of HH, LH and HL, namely from the rearmost in the quasi image coded data as shown in FIG. 9 (Step S1506). In this deletion of the entropy  
 10 coded value in the unit of sub-bands, bit planes comprised of respective digits of the code in the sub-band as shown in FIG. 10 are defined, and bit planes are deleted in ascending order with the lowest bit plane being deleted first.

15 On the other hand, if the code length of quasi image coded data is smaller than the designated code length (Step S1505), the adjustment bit comprised of bits "0" is added to the rear of the HH3 sub-band as shown in FIG. 11. (Step S1507). When the quasi image coded data is decoded, the  
 20 no adjustment bit is decoded. Thus, in order that the decoding device can correctly decode the image coded data with adjustment bits added thereto, the code length of this adjustment bit is written in the header, as described above (Step S1508).

25 The image coded data generated as described above is outputted from an image coded data outputting unit 115 to the frame coded data generation unit 107 (Step S1509).

On the other hand, a flowchart of processing of encoding voice data in the voice data coding unit 105 in Step S1404 is shown in FIG. 16, and explanation thereof will be given using this figure.

5       Voice data to be encoded in the frame in this embodiment is inputted from the voice data inputting unit 116, and is outputted to a discrete wavelet transformation unit B117.

10       The discrete wavelet transformation unit B117 performs discrete wavelet transformation on voice data inputted from the voice data inputting unit 116 to generate voice coded data (Step S1601).

15       The voice coded data generated by the discrete wavelet transformation unit B117 is outputted to a voice coded data outputting unit 118, and is outputted from the voice coded data outputting unit 118 to the frame coded data generation unit 107 (Step S1602).

Also, the program code complying with the above described flowchart is stored in a memory such as a RAM and ROM, and is read out and executed by the CPU.

20       As described above, in the coding device and coding method in this embodiment, when image data in frame data is encoded, discrete wavelet transformation is used to generate image coded data, and image coded data in each frame coded data is subjected to length fixation. As a  
25       result, the outline of the original image is displayed within a time period over which one frame data is played back in spite of partial decoding of image coded data. Also,

image decoded data is subjected to length fixation, whereby time required for decoding is reduced, thus making it possible to start the decoding of voice coded data immediately after partial decoding.

5           [second Embodiment]

When frame coded data is decoded and the decoded image data is displayed, it may be required that the decoding and display should be performed more quickly than at least the decoding and display of image data in the first embodiment, 10 for only the outline of the image of each frame. In this case, only the LL sub-band of each image coded data may be decoded and displayed. For decoding and displaying the LL sub-band of each image coded data more quickly than the case of the first embodiment, the LL sub-band of each image coded 15 data should be fetched in a predetermined buffer at one time without excess and deficiency. That will be achieved if the LL sub-band in each image coded data is length-fixed to a predetermined code length. In this embodiment, a coding device and coding method for encoding each image data 20 so that the component of the LL sub-band of each image coded data is length-fixed will be presented.

A block diagram showing a configuration of the coding device in this embodiment is shown in FIG. 12. The coding device in this embodiment has replaced with an image coded 25 data generation unit B1201 the image coded data generation unit A114 constituting the image data coding unit 106 shown in FIG. 1C in the first embodiment. All the units of the

coding device and operations thereof other than the image coded data generation unit in this embodiment are same as those of the coding device in the first embodiment.

The entropy coded value generated by the entropy coding unit 113 based on the factor quantized value inputted from the factor quantization unit 112 is inputted in the image coded data generation unit B1201 as in the case of the first embodiment, and quasi image coded data as shown in FIG. 8 is generated as in the case of the first embodiment.

10           If the code length of the LL sub-band in quasi image  
coded data is larger than the code length designated by the  
designated image coded data code length inputting unit 102,  
bits are deleted in ascending order, with the bit in the  
lowest bit plane of bit planes constituting the LL sub-  
15 band being deleted first.

On the other hand, if the code length of the LL sub-band in quasi image coded data is smaller than the code length designated by the designated image coded data code length inputting unit 102, the adjustment bit described in the first embodiment is added to the rear of the LL sub-band. As a result, the code length of LL sub-bands included in all image coded data is all equalized (to the code length designated by the designated image coded data code length inputting unit 102), resulting in length fixation.

25        In this way, image coded data is generated, and is  
inputted in the image coded data outputting unit 115. And,

processing thereafter is same as that of the first embodiment.

Furthermore, the LL sub-band designated by the designated image coded data code length inputting unit 102  
5 shall be a code length such that decoding and displaying of the data can be performed more quickly than at least the decoding and displaying of image data in the first embodiment for only the outline of the image of each frame.

Furthermore, the flowcharts of generation of frame  
10 coded data and voice coded data in this embodiment are same as those in FIGS. 14 and 16, respectively, but the flowchart of generation of image coded data is a flowchart with the following changes made to processing in each step in FIG. 15.

15 First, the processing in Step S1505 is considered as processing of comparing the designated code length to the code length of the LL sub-band. And, if the code length of the LL sub-band is larger than the designated code length, the processing in Step S1506 is considered as processing  
20 of deleting bits in ascending order, with the bit in the lowest bit plane of bit planes constituting the LL sub-band being deleted first.

On the other hand, if the code length of the LL sub-band is smaller than the designated code length, the processing  
25 in Step S1507 is considered as processing of adding the adjustment bit to the LL sub-band.

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Also, the program code complying with the above described flowchart is stored in a memory such as a RAM and ROM, and is read and executed by the CPU.

Furthermore, in this embodiment, the case where length  
5 fixation of the LL sub-band is performed has been described, but the present invention is not limited thereto. For example, four sub-bands of LL, LH1, HL1 and HH1 are considered as the low frequency sub-band and the total length of these four sub-bands is made to be a fixed length  
10 by the above described method, whereby the object of this embodiment is also achieved.

As described above, the coding device and coding method in the second embodiment performs length fixation of only the LL sub-band in each image coded data, thereby making  
15 it possible to perform the decoding and display for only the outline of the image of each frame (image corresponding to the low frequency component) more quickly than the decoding and displaying of image data in the first embodiment.

#### 20 [Third Embodiment]

In a server/client model, the server transmits data that the client demands. In this transmission, due to difference in data transfer capacity of the line connecting the server to the client and so on, the amount of data that  
25 each client demands from the server is varied. Therefore, a part or all of the data that the server accumulates in accordance with the amount of data that the client demands

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is fetched. Furthermore, if a part of data is fetched, the data must be fetched in the unit of data (unit data) such that significant data is generated after decoding. For example, image coded data subjected to discrete wavelet transformation may be fetched in the unit of sub-band.

Also, when unit data is fetched, importance may be placed on the speed at which the data is fetched. For example, if each sub-band is length-fixed to a predetermined code length (namely, if sub-bands with same types/same frequencies belonging to each frame are coded data of same length), image coded data subjected to discrete wavelet transformation can be fetched more quickly than the case where no length fixation is made.

In this embodiment, a coding device and coding method will be shown in which image data in frame data is divided into a plurality of sub-bands through discrete wavelet transformation and each sub-band is length-fixed (namely, at least sub-bands with same types/same frequencies belonging to each frame are length-fixed) so that the server can fetch image data in the sub-band unit at high speed.

A configuration of the coding device in this embodiment is shown in FIG. 13. The coding device in this embodiment has replaced with an image coded data generation unit C1301 the image coded data generation unit A114 constituting the image data coding unit 106 shown in FIG. 1C in the first embodiment. All the units of the coding device and operations thereof other than the image coded data



generation unit in this embodiment are same as those of the coding device in the first embodiment.

The entropy coded value generated by the entropy coding unit 113 based on the factor quantized value inputted from the factor quantization unit 112 is inputted in an image coded data generation unit C1201 as in the case of the first embodiment, and quasi image coded data as shown in FIG. 8 is generated as in the case of the first embodiment.

If the code length of each sub-band in quasi image coded data is larger than the code length designated for that kind of sub-bands, it is limited to the code length predetermined for that kind of sub-bands by deleting bits in ascending order, with the bit in the lowest bit plane of bit planes constituting each sub-band being deleted first.

Specifically, the code length is predetermined for each of LL, HL1, LH1, HH1, ..., LH3, HH3, for example. In other words, a limitation is imposed in such a manner that LLs, LH1s, ... of certain two frames (or more) are expressed by coded data of same code lengths, respectively.

On the other hand, if the code length of each sub-band in quasi image coded data is smaller than the designated code length, the adjustment bit is added to the rear of each sub-band. Consequently, the code length of respective sub-bands of same kinds in a plurality of frames is all equalized (to the code length designated by the designated image coded data code length inputting unit 102), resulting in length fixation. In this way, image coded data

is generated, and is inputted in the image coded data outputting unit 115. And, each processing thereafter is same as that of the first embodiment.

Furthermore, the flowcharts of generation of frame coded data and voice coded data in this embodiment are same  
5 as those in FIGS. 14 and 16, respectively, but the flowchart of generation of image coded data is a flowchart with the following changes made to processing in each step in FIG. 15.

10 First, the processing in Step S1505 is considered as processing of comparing the designated code length to the code length of each sub-band in quasi image coded data. And, if the code length of each sub-band in quasi image coded data is larger than the designated code length, the  
15 processing in Step S1506 is considered as processing of deleting bits in ascending order, with the bit in the lowest bit plane of bit planes constituting each sub-band being deleted first.

On the other hand, if the code length of each sub-  
20 band in quasi image coded data is smaller than the designated code length, the processing in Step S1507 is considered as processing of adding the adjustment bit to each sub-band.

Also, the program code complying with the above  
25 described flowchart is stored in a memory such as a RAM and ROM, and is read and executed by the CPU.

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As described above, in the coding device and coding method in the third embodiment, the code length of each sub-band of image coded data included in frame coded data is all equalized and length-fixed at least in the same kind of sub-bands, whereby, for example, the server can fetch data in the unit of sub-bands more speedily than the case where no length fixation is made.

Furthermore, since the above described sub-band has a different number of factors (size) depending on the frequency level, explanation has been given on the premise that the code length at least in the same kind of sub-bands is equalized, but the present invention is not limited thereto. In other words, for four kinds of sub-bands of LL, HL1, LH1 and HH1 in all frames, such coded data as identical in code length to one another may be used for expression. In the same way, for three kinds of sub-bands of HL2, LH2 and HH2, coded data such that their code lengths are equalized may be used for expression. In the same way, for three kinds of sub-bands of HL3, LH3 and HH3, coded data such that their code lengths are equalized may be used for expression. In the present invention, since being able to understand where data of each sub-band exists for each of coded data of a plurality of frames is enough, the object of the present invention is achieved as long as at least the "boundary" of coded data of each sub-band can be recognized.

[Fourth Embodiment]

When frame coded data is decoded, it may be required that coded data (a plurality of sub-bands) expressing the image of each frame be fetched in the unit of resolution level to display the image of designated resolution at high speed. That is, if making considerations in the light of the state of the sub-band after wavelet transformation, the above described resolution level can be understood as, for example, level 0 = <LL>, level 1 = <HL1, LH1, HH1>, level 2 = <HL2, LH2, HH2>, level 3 = <HL3, LH3, HH3>.

10 For decoding the image of designated resolution at high speed, each image coded data should be fetched in the unit of level in a work buffer at one time without excess and deficiency. That will be achieved if image coded data expressing the image of each frame is length-fixed in the unit of level. For this embodiment, a coding device and coding method for encoding each image data so that each image coded data is length-fixed in the unit of level will be presented.

A block diagram showing the configuration of the coding device in this embodiment is shown in FIG. 17. The coding device in this embodiment has replaced with an image coded data generation unit D1701 the image coded data generation unit A114 constituting the image data coding unit 106 in the first embodiment shown in FIG. 1C. All the units of the coding device and operations thereof other than the image coded data generation unit in this embodiment are same as those of the coding device in the first embodiment.

The entropy coded value generated by the entropy coding unit 113 based on the factor quantized value inputted from the factor quantization unit 112 is inputted in the image coded data generation unit D1701 as in the case of the first embodiment, and quasi image coded data as shown in FIG. 8 is generated as in the case of the first embodiment.

For this embodiment, if the code length of each level in quasi image coded data is larger than the code length designated in advance for each level by designated image coded data code length inputting unit 102, coded data is deleted/reduced in the order of HHn, LHn and HLn sub-bands. Furthermore, in deletion/reduction of coded data of these sub-bands, bit planes are deleted in ascending order with the lowest bit plane being deleted first (in the case of level 1 or higher).

In the same way, when coded data of the sub-band LL of the lowest frequency component is deleted/reduced (in the case of level 0), bit planes are deleted in ascending order with the lowest bit plane being deleted first.

On the other hand, if the code length of each level in the quasi image coded data is smaller than the code length designated by the designated image coded data code length inputting unit 102, the adjustment bit described in the first embodiment is added to the rear of the HH sub-band of each level, for level 1. Furthermore, for level 0, the adjustment bit is added to the rear of the LL sub-band as a matter of course. Consequently, the code length of each

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level unit included in image coded data of all frames is all equalized (to the code length designated for each level by the designated image coded data code length inputting unit 102), resulting in length fixation.

5       As described above, image coded data is generated, and is inputted in the image coded data outputting unit 115. And, each processing thereafter is same as that of the first embodiment.

10       Furthermore, the flowcharts of generation of frame coded data and voice coded data in this embodiment are same as those in FIGS. 14 and 16, respectively, but the flowchart of generation of image coded data is a flowchart in FIG. 18 with the following changes made to processing in FIG. 15.

15       First, the processing in Step S1505 is considered as processing of comparing the designated code length to the code length of each level. And, if the code length of each sub-band is larger than the designated code length, the processing in Step S1506 is considered as processing of  
20 deleting/reducing bits in the order of HH, LH and HL (only LL in the case of level 0) in each level, and in the sub-band, deleting/reducing bits in the lowest bit plane first.

25       On the other hand, if the code length of each level is smaller than the designated code length, the processing in Step S1507 is considered as processing of adding the adjustment bit to the rear of the HH sub-band (to the rear of the LL sub-band in the case of level 0).

Furthermore, in Steps S1505, S1506, S1507 and S1508, repetition processing of the level number of times is performed.

Also, the program code complying with the above  
5 described flowchart is stored in a memory such as a ROM and RAM, and is read and executed by the CPU.

As described above, in the coding device and coding method in this embodiment, the code length is length-fixed in the unit of each level in image coded data expressing  
10 each frame, thereby making it possible to display each frame with designated resolution at high speed.

#### [Alterations of the Above Embodiments]

In all the embodiments, the leading address of each frame data may be written in the header for performing the  
15 partial decoding of each frame data at high speed.

Also, in the second embodiment, the leading address of each frame coded data may be written in the header after the partial decoding of each image coded data, for decoding voice coded data more quickly.

#### 20 [Fifth Embodiment]

In this embodiment, as in the case of the second embodiment, the case where quick playback (playback of the motion image at frame rates of one to n-fold speeds) is performed efficiently by the length fixation of coded data  
25 of the LL sub-band corresponding to the low frequency component in each frame will be described.

In some cases, a frame decoding device performs playback at the speed any several times as high as a normal playback speed (arbitrary multiple speed playback). At this time, if coded data required for playback is  
5 length-fixed among a plurality of frames, the arbitrary multiple speed playback can be performed efficiently. This is because the frame decoding device needs to obtain the leading address and code length of the coded data from the header for taking out the coded data in a work area,  
10 if the coded data is not length-fixed. If the coded data is length-fixed, however, the coded data can be fetched in the work area if only the leading address of the coded data is obtained.

Thus, in this embodiment, a frame coding device  
15 performing the length fixation of coded data required for efficiently carrying out arbitrary multiple speed playback is provided, and a frame decoding device for efficiently carrying out arbitrary multiple speed playback of the frame coded data generated by the frame coding device is provided.

20 Furthermore, in this embodiment, data that is length-fixed among frames (referred to as unit data) is considered as the LL sub-band. Furthermore, the concept of the fixed length is similar to that of the second embodiment.

25 <Frame Coding Device>

A block diagram showing the configuration of the frame coding device in this embodiment is shown in FIG. 36C.



The frame coding device in this embodiment has replaced with a frame data coding unit A3607 the frame data coding unit 101 in the coding device of the first embodiment shown in FIG. 1A. The reason why this replacement is applied is  
5 that unit data is the whole image coded data in the first embodiment, but unit data in this embodiment is the LL sub-band. Operations in the designated image coded data code length inputting unit 102 are identical to those of the same processing unit in the first embodiment.

10 Furthermore, in this embodiment, the code length of the above described unit data is called a target code length.

FIG. 36A is a graphic view of a configuration of a frame data coding unit A in a frame coding device in this  
15 embodiment. In this figure, reference numerals 103, 104, 105, 3601, 3606 and 108 denote a frame data inputting unit, a frame data division unit, a voice data coding unit, an image data coding unit A, a frame coded data generation unit A and a frame coded data outputting unit, respectively.

20 Contents of processing in the frame data coding unit A in this embodiment are similar to those in the frame data coding unit 101 in the first embodiment, except for the image data coding unit 3601 and the frame coded data generation unit A 3606.

25 Furthermore, a difference in processing between the frame coded data generation unit A3606 in this embodiment and the frame coded data generation unit 107 in the first

embodiment lies in different information written in the header by these generation units. That is, the frame coded data generation unit A3606 in this embodiment writes not only information written in the header by the frame coded data generation unit 107 but also information showing unit data and the target code length in the header in the first embodiment.

Processing in the image data coding unit A3601 will be described below.

FIG. 36B shows in diagrammatic form the specific configuration of the image data coding unit A3601 in FIG. 36A. In this figure, reference numerals 109, 3602, 111, 3603, 3604, 3605 and 115 denote an image data inputting unit, a discrete wavelet transformation unit A, a buffer, a factor quantization unit A, an entropy coding unit A, an image coded data generation unit D and an image coded data outputting unit, respectively. The image data coding unit A3601 in this embodiment has the discrete wavelet transformation unit 110, the factor quantization unit 112, the entropy coding unit 113 and the image coded data generation unit A114 in the above described FIG. 1C with the discrete wavelet transformation unit A3602, the factor quantization unit A3603, the entropy coding unit A3604 and the image coded data generation unit D3605, respectively. Each portion of the image data coding unit A3601 will be described below with emphasis on portions characteristic of this embodiment.

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As shown in FIGS. 19A and 19B, the discrete wavelet transformation unit A3602 repeats division by wavelet transformation in the lateral and vertical direction to generate seven sub-bands. These seven sub-bands are  
5    outputted to the buffer 111, and are further outputted to the factor quantization unit A3603.

In the factor quantization unit A3603, the factor belonging to each sub-band inputted is quantized to become a factor quantized value, as shown in FIG. 20. This factor  
10    quantized value is outputted to the entropy coding unit A3604.

In the entropy coding unit A3604, each sub-band, which is a group of inputted factor quantized values, is divided into rectangular forms (referred to as a code blocks), as  
15    shown in FIG. 21. Furthermore, the size of this code block is defined as  $2m \times 2n$  ( $m$  and  $n$  are integers equal to or greater than 1) or the like. In addition, this code block is divided into bit planes as shown in FIG. 22. Furthermore, as shown in FIG. 23, bits in a certain bit plane are grouped into  
20    three types based on a classification rule, and three kinds of coding passes gathering a same type of bits are thus generated. The inputted factor quantized value is subjected to binary arithmetic coding, which is entropy coding, with the coding pass obtained here as a unit, to  
25    generate an entropy coded value.

Furthermore, for specific order of processing of entropy coding here, coding is performed in the order of

from the highest plane bit to the lowest plane bit if watching a single coding block, and three kinds of passes shown in FIG. 23 are coded in descending order if watching a bit plane in the single coding block.

5       The entropy coded values are outputted to the image coded data generation unit D3605. The entropy coded values inputted in the image coded data generation unit D3605 are arranged in the unit of sub-bands to form quasi image coded data as shown in FIG. 8. If a desired bit rate (compression  
10       rate to the amount of original image data) is not achieved yet, data is deleted with the least important data being deleted first, with a coding pass as a unit.

15       In this embodiment, the LL sub-band is further subjected to length fixation before image coded data is formed, as will be described below.

20       If the LL sub-band in the code length of quasi image coded data is larger than the target code length designated by the designation image coded data code length inputting portion 102, data in the LL sub-band that is considered less  
25       important is deleted. As one form of this deletion, deletion in ascending order with the bit plane in the code block included in the LL sub-band as a unit can be considered. Also, as another form of deletion, deletion in ascending order with the coding pass in the code block included in  
the LL sub-band as a unit can also be considered.

On the other hand, if the LL sub-band in the code length of quasi image coded data is smaller than the target code

length designated by the designation image coded data code  
length inputting portion 102, a marker indicating embedment  
of a message that should be given to a decoding end (comment  
marker) and some message data (comments) are inserted in  
5 header information at the head of coded data of the frame  
to be encoded. Also, dummy data to the LL sub-band is added.  
This dummy data is pseudo data required for rendering the  
encoded image data the code amount n byte (n: integer) of  
length fixation. Furthermore, it is further desirable  
10 that this dummy data is considered as auxiliary data for  
correcting an error of coded data of the LL sub-band, for  
using this dummy data effectively.

Image coded data generated as described above is  
outputted from the image coded data outputting unit 115 to  
15 the frame coded data generation unit 108.

#### <Frame Decoding Device>

The frame decoding device in this embodiment not only  
can decode the entire data of the frame coded data generated  
as described above (normal decoding) and play back the  
20 decoded image generated at normal speed (normal playback),  
but also fetch only a part of data to decode the same (quick  
decoding) and play back the decoded image generated at high  
speed (quick playback).

Furthermore, in this embodiment, it is desirable that  
25 the LL sub-band is an object to be decoded in the case of  
quick playback as the above described part of data because  
the LL sub-band is length-fixed.

Furthermore, explanation will be given, for this embodiment, on the premise that the amount of coded data of the LL sub-band is about 1/16 of the amount of entire coded data including other sub-bands, and for quick  
5 decoding (playback) in this embodiment, it is preferred data in performing sixteen-fold-speed playback, in order to simplify the explanation.

However, it should also be noted that in fact, the amount of coded data of the LL sub-band is usually larger  
10 than 1/16 of the amount of entire coded data because the coding efficiency of the LL sub-band is not high compared with other sub-bands.

FIG. 24 is a block diagram of the frame decoding device in this embodiment. In this figure, reference numerals  
15 2401, 2402, 2403, 2404 and 2405 denote a frame coded data accumulation unit, a normal decoding unit, a fixed length fetching unit, a quick decoding unit and a played image display unit, respectively.

A flow of processing in terms of the frame decoding  
20 device in this embodiment will now be described, using FIG. 25.

Frame coded data inputted in the frame decoding device in this embodiment is accumulated in the frame coded data accumulation unit 2401. If normal decoding is carried out,  
25 the frame coded data to be decoded is fetched in the normal decoding unit 2402 (S2501), and decoding of the frame coded data is performed (S2502). On the other hand, if quick

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decoding is carried out, only the LL sub-band in the frame  
coded data to be decoded is fetched in the quick decoding  
unit 2404 by the fixed length fetching unit 2403 (S2503),  
and decoding of the LL sub-band is performed (S2504). After  
5 that, the decoded image obtained by normal decoding or quick  
decoding is displayed on the played image display unit 2405  
(S2505).

Processing of decoding frame coded data in the normal  
decoding unit 2402 will now be described.

10 FIG. 26 is a block diagram of the normal decoding unit  
2402 in this embodiment. In this figure, reference  
numerals 2601, 2602, 2603, 2604, 2605 and 2606 denote a  
frame coded data inputting unit, an entropy decoding unit,  
an inverse quantization unit, a buffer A, an inverse  
15 discrete wavelet transformation unit A and a decoded frame  
data outputting unit 2606.

A flow of processing in terms of the normal decoding  
unit 2402 will now be described.

When a code string sent from the frame coded data  
20 accumulation unit 2401 is inputted in the frame coded data  
inputting unit 2601, the frame coded data is divided into  
header information, image coded data and voice coded data,  
and the image coded data is outputted to the entropy  
decoding unit 2602. Furthermore, the voice coded data is  
25 decoded by a decoding unit (not shown), but such decoding  
processing is not described here because decoding of voice

coded data is not concerned with the substance of the present invention.

The entropy decoding unit 2602 subjects the fetched image coded data to decoding processing to restore the quantized value. Then, the restored quantized value is outputted to the inverse quantization unit 2603. The inverse quantization unit 2603 subjects the inputted quantized value to inverse quantization, thereby restoring the discrete wavelet transformation factor and outputs the same to the following buffer A 2604. Inverse quantization is carried out according to the equation described below.

$$X_r = Q \times q$$

wherein  $Q$ ,  $q$  and  $X_r$  represent a quantized value, a quantizing step and a restored discrete wavelet transformation factor, respectively.

The discrete wavelet transformation factor stored in the buffer A2604 is inputted in the inverse discrete wavelet transformation unit A2605 by each level. In the inverse discrete wavelet transformation unit A2605, inverse discrete wavelet transformation is performed based on the equations described below.

$$x(2n) = r(n) + \text{floor}\{p(n)/2\}$$

$$x(2n+1) = r(n) - \text{floor}\{p(n)/2\}$$

where:

$$p(n) = d(n-1) - \text{floor}\{(-r(n) + r(n+2) + 2)/4\}$$

wherein the discrete wavelet transformation factor of the low frequency component is represented by  $r(n)$ , and



the discrete wavelet transformation factor of the high frequency component is represented by  $d(n)$ . Also,  $x(n)$  represents decoded data. This equation of transformation is for one-dimensional data, but two-dimensional

5 transformation is performed by applying this transformation in order of lateral direction and vertical direction. Then, decoded image data is generated, and is outputted to the decoded frame data outputting unit 2606. This decoded frame data outputting unit 2606 combines voice  
10 data decoded (decoded voice data) and decoded image data to generate frame decoded data. This frame decoded data is outputted to the played image display unit 2405.

The quick decoding unit 2404 will now be described.

The quick decoding unit 2404 in this embodiment decodes  
15 only the LL sub-band fetched by the fixed length data fetching unit 2403. Decoding processing itself in this case is usually performed substantially as in the case of the normal decoding unit 2402, and therefore detailed description thereof is not particularly presented.

20 As described above, coded data corresponding to the frequency component of a part of the image is length-fixed, whereby both image playback at normal speed and image playback at high speed can efficiently be performed.

Furthermore, in this embodiment, since the resolution  
25 of the decoded image obtained by decoding processing in the case of the above described quick playback is low,

processing of changing the resolution of the image as appropriate for the decoded image is preferably added.

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This embodiment is also characterized by performing image processing for improving image quality of the decoded image as far as practical, depending on the speed of quick  
5 playback. In other words, in this embodiment, for any quick playback of double-speed, triple-speed, quadruple-speed, ..., sixteen-fold-speed, processing for increasing resolution (data interpolation) and processing for  
10 improving image quality (smoothing and the like) are performed in the interval between decoding and playback if only the LL sub-band is decoded/played back at modest playback speed such as double-speed and quadruple-speed, even provided that only the LL sub-band of fixed length must  
15 be decoded/played back because there is no time for performing normal decoding. By so doing, the image of highest possible quality can be played back even in quick playback.

In the fifth embodiment, as described above, in a  
20 configuration in which image data expressing each frame in the motion image is subjected to discrete wavelet transformation before it is encoded, the portion corresponding to the low frequency LL sub-band is further length-fixed among frames, thereby making it possible to  
25 perform quick playback smoothly.

[Sixth embodiment]

In this embodiment, the case where coded data of the same kind of sub-bands in each frame are length-fixed, thereby performing efficiently quick playback (playback of the motion image at frame rates of one to n-fold speeds) as in the case of the third embodiment will be described.

In the fifth embodiment, the case where only coded data of the LL sub-band subjected to length fixation is decoded to perform playback and display in the case of double-speed to sixteen-fold-speed decoding/playback has been described. However, it is also desired that decoding/playback a little more faithful to the original image should be performed in the case of double-speed and quadruple-speed decoding/playback.

Thus, for image coded data in this embodiment, length fixation of coded data is carried out for each sub-band, thereby performing each quick playback of the motion image in multi-level image quality in accordance with the playback speed.

#### <Frame Coding Device>

A block diagram showing a configuration of a frame coding device in this embodiment is shown in FIG. 42A. The frame coding device in this embodiment has replaced with a frame data coding unit B4201 the frame data coding unit A3607 in the coding device shown in FIG. 36C in the fifth embodiment. The reason why this unit is replaced is that unit data is the LL sub-band in the fifth embodiment, but unit data in this embodiment is each sub-band. Operations

in the designated image coded data code length inputting unit 102 are same as those in the unit in the fifth embodiment, and therefore detailed description thereof is not presented.

5           FIG. 42B shows in diagrammatic form the configuration of the frame data coding unit in the frame coding device in this embodiment. In this figure, reference numerals 103, 104, 105, 4202, 3606 and 108 denote a frame data inputting unit, a frame data division unit, a voice data coding unit, 10 an image data coding unit B, a frame coded data generation unit A and a frame coded data outputting unit. As apparent from this figure, contents of processing in the frame data coding unit in this embodiment are similar to those in the frame data coding unit in the fifth embodiment except for 15 the image data coding unit.

          A block diagram showing the configuration of the image coding device in this embodiment is shown in FIG. 37. The image data coding unit B4202 in this embodiment has replaced with an image coded data generation unit E3701 the image 20 coded data generation unit D3605 constituting the image data coding unit A3601 shown in FIG. 36B in the fifth embodiment. Except for that point, the image coding device and operations thereof in this embodiment are same as the image coding device and operations thereof in the fifth 25 embodiment, and therefore detailed description thereof is not presented.

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In the image coded data generation unit E3701 in this embodiment, length fixation for each sub-band is carried out as shown in FIG. 27. The concept of this length fixation is similar to that in the fifth embodiment.

5 As a result, in the frame decoding device, efficient quick decoding that also copes with speeds other than the sixteen-fold-speed can be performed. The state thereof is shown in FIG. 28. For example, in the case where  
10 since there are sufficient time/loads to decode sub-bands other than the LL sub-band, two sub-bands of LL and HL1 of each frame as shown in FIG. 28A are fetched and decoded, thereby making it possible to achieve eight-fold-speed playback in high image quality.

15 Four sub-bands of LL, LH1, HL1 and HH1 are usually played back in the case of using a part of sub-bands subjected to wavelet transformation to perform decoding/playback, but in this embodiment, at least HL1 is decoded together with LL considering the playback speed  
20 (eight-fold-speed), thereby making it possible to play back a highest possible image suited to the playback speed.

Furthermore, to describe the case of double-speed playback in a similar way, coded data accounting for substantially 1/2 of the amount of the entire coded data  
25 is decoded as shown in FIG. 28B, thereby making it possible to perform playback of high image quality suited to the playback speed.

Furthermore, in this embodiment, the sub-band HH2 is not used in the case of quick playback, and therefore this part does not need to be length-fixed. In other words, this embodiment is characterized in that two or more kinds of sub-bands that could be an object to be decoded in the case of quick (special) playback are length-fixed.

#### <Frame Decoding Device>

The decoding device in this embodiment is shown in FIG. 49. This has the fixed length data fetching unit 2403 and the quick decoding unit 2404 in the fifth embodiment with a fixed length fetching unit 4901 and a quick decoding unit 4902. The reason why these units are replaced is that while data treated with quick decoding is only the LL sub-band in the fifth embodiment, data treated with quick decoding in this embodiment is the length-fixed sub-band including the LL sub-band. Furthermore, processing performed by the frame decoding device in this embodiment is substantially similar to processing performed by the frame decoding device in the fifth embodiment, and therefore detailed description of the frame decoding device in this embodiment is not presented.

In this embodiment, as described above, a same kind of sub-bands in mutual frames are made to take on the fixed length, whereby two or more kinds of sub-bands equivalent to the amount of coded data that sufficiently keeps with the playback speed are decoded, thus making it possible to

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perform image playback of high image quality suited to the playback speed.

[Seventh Embodiment]

In this embodiment, the case where coded data is  
5 length-fixed in the unit of sub-band groups belonging to a same kind of resolution levels in each frame, thereby performing quick playback (playback of the motion image at frame rates of 1 to n-fold speeds) efficiently, as in the case of the fourth embodiment will be described.  
10 Furthermore, as described above, the level of resolution refers to groups of sub-bands like, for example, level 0 = <LL>, level 1 = <HL1, LH1, HH1>, and level 2 = <HL2, LH2, HH2>, if considering the state of the sub-band after wavelet transformation.

15 <Frame Coding Device>

A block diagram showing the configuration of the frame coding device in this embodiment is shown in FIG. 43A. The frame coding device in this embodiment has replaced with a frame data coding unit C4301 the frame data coding unit  
20 A3607 in the coding device shown in FIG. 36C in the fifth embodiment. The reason why this replacement is applied is that unit data is the LL sub-band in the fifth embodiment, but unit data in this embodiment is the level of resolution. Operations in the designated image coded data code length  
25 inputting unit 102 are same as those in this processing unit in the fifth embodiment, and therefore description thereof is not presented.

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FIG. 43B shows in diagrammatic form the configuration of the frame data coding unit in the frame coding device in this embodiment. In this figure, reference numerals 103, 104, 105, 4302, 3606 and 108 denote a frame data inputting unit, a frame data division unit, a voice data coding unit, an image data coding unit C, a frame coded data generation unit A and a frame coded data outputting unit, respectively. Contents of processing in the frame data coding unit in this embodiment are similar to those in the frame data coding unit in the fifth embodiment except for the image data coding unit, and therefore detailed description thereof is not presented.

A block diagram showing the configuration of the image coding device in this embodiment is shown in FIG. 38. The coding device in this embodiment has replaced with an image coded data generation unit F3801 the image coded data generation unit D3605 constituting the image data coding unit A3601 shown in FIG. 36B in the fifth embodiment. Except for that point, the image coding device and operations thereof are same as the image coding device and operations thereof in the fifth embodiment.

In the image coded data generation unit F3801 in this embodiment, coded data is length-fixed for each group of sub-bands belonging to a same kind of resolution levels. That is, for each frame, coded data representing LL are length-fixed so that they are rendered the code length C0, a group of coded data representing three sub-bands of HL1,



LH1 and HH1 are length-fixed so that they are rendered the code length C1, and a group of coded data representing three sub-bands of HL2, LH2 and HH2 are length-fixed so that they are rendered the code length C2.

5       As a result, as shown in FIG. 30, the frame decoding device of this embodiment can perform decoding/playback of only the resolution level suited to the playback speed. In FIG. 30, only coded data of the length-fixed LL sub-band (namely, level 0) can be decoded/played back in the case  
10 of (five-fold-speed to) sixteen-fold-speed playback, and only coded data representing three sub-bands of HL1, LH1 and HH1 (level 1) together with the LL sub-band can be decoded/played back in the case of (double-speed to) quadruple-speed playback.

15       Furthermore, in the case shown in FIG. 30, since LH2, HL2 and HH2 belong to a sub-band group of highest resolution level, length fixation does not need to be performed for this group of highest level, for attaining the object of this embodiment.

20       In this embodiment, the object can be attained as long as at least coded data of resolution level (sub-band group) for which partial playback could be applied when quick playback is carried out.

#### <Frame Decoding Device>

25       The decoding device in this embodiment is shown in FIG. 50. This device has the fixed length data fetching unit 2403 and the quick decoding unit 2404 in the fifth

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embodiment replaced with a fixed length data fetching unit 5001 and a quick decoding unit 5002. The reason why these units are replaced is that while data treated with quick decoding in only the LL sub-band in the fifth embodiment, 5 data treated with quick decoding in this embodiment is coded data of resolution level. Furthermore, processing performed by the frame decoding device in this embodiment is substantially similar to processing performed by the frame decoding device in the fifth embodiment, and 10 therefore detailed description of processing of the frame decoding device in this embodiment is not presented.

As described above, according to this embodiment, since image coded data are length fixed for each coded data of the group of sub-bands belonging to each resolution level, 15 a image of highest possible quality suited to the playback speed can be played back when these coded data are played back at high speed.

#### [Eighth Embodiment]

In the fifth embodiment, only the LL sub-band that is 20 the lowest frequency component is length-fixed.

However, the present invention is not limited thereto. For example, the object of the present invention is attained even if four sub-bands of LL, LH1, HL1 and HH1 are considered as low frequency sub-bands, and the sum of these four 25 sub-bands is made to be length-fixed. In this embodiment, this case will be described.

In the case where the number of times discrete wavelet transformation is repeatedly performed in lateral and vertical directions of the image (the level number) is large, length fixation of only the LL sub-band may be impractical.

5 For example, the level number of discrete wavelet transformation described for the first embodiment is 3, and therefore if length fixation of the LL sub-band in the image coded data is performed, this represents a form of optimum coded data for performing sixty four-fold-speed  
10 decoding/playback, which is less practical.

Thus, in this embodiment, coded data of the sub-band group including the LL sub-band and other low frequency sub-bands, though not all of various kinds of sub-bands, are length-fixed.

15 A block diagram showing the configuration of the frame coding device in this embodiment is shown in FIG. 44A. The frame coding device in this embodiment has replaced with a frame data coding unit D4401 the frame data coding unit A3607 in the coding device in the fifth embodiment shown  
20 in FIG. 36C. The reason why this replacement is applied is that unit data in the fifth embodiment is the LL sub-band, but unit data in this embodiment is the LL sub-band +  $\alpha$  (LH1, LH1, HH1...). Operations in the designated image coded data code length inputting unit 102 are similar to those  
25 in the same processing unit in the fifth embodiment.

FIG. 43B shows in diagrammatic form the configuration of the frame data coding unit in the frame coding device

in this embodiment. In this figure, reference numerals 103, 104, 105, 4402, 3606 and 108 denote a frame data inputting unit, a frame data division unit, a voice data coding unit, an image data coding unit D, a frame coded data generation unit A and a frame coded data outputting unit, respectively. Contents of processing in the frame data coding unit in this embodiment are similar to those in the frame data coding unit in the fifth embodiment except for the image data coding unit, and therefore detailed description thereof is not presented.

Now, a block diagram showing the configuration of the image coding device in this embodiment is shown in FIG. 39. In this embodiment, since the case where the level number of discrete wavelet transformation is 3 will be described, the discrete wavelet transformation unit 110 and the factor quantization unit 112 used in the first embodiment are applied for a discrete wavelet A3802 and a factor quantization unit A3803. Also, the image coded data generation unit D3605 constituting the image data coding unit A3601 shown in FIG. 36B in the fifth embodiment is replaced with an image coded data generation unit G3901 described later. Also, because of difference in the number of sub-bands treated, the entropy coding unit A3604 is replaced with an entropy coding unit B3902 in FIG. 39 described above. However, basic processing remains unchanged, and therefore detailed description thereof is not presented.

As shown in FIG. 32, the image coded data generation unit G3901 in this embodiment length-fixes the coded data corresponding to the sub-band group of the LL sub-band + $\alpha$ (LH1, HL1, HH1, LH2, HL2, HH2). This point represents a significant difference between this embodiment and the fifth embodiment.

A configuration as shown in FIG. 32 makes it possible to play back easily a simple image most suitable for performing quadruple-speed decoding/playback, which is a very practical setting.

#### <Frame Decoding Device>

The decoding device in this embodiment is shown in FIG. 51. This device has the fixed length data fetching unit 2403 and the quick decoding unit 2404 in the fifth embodiment replaced with a fixed length data fetching unit 5101 and a quick decoding unit 5102. The reason why these units are replaced is that while data treated with quick decoding is only the LL sub-band in the fifth embodiment, data treated with quick decoding in this embodiment is the LL sub-band +  $\alpha$ (LH1, HL1, HH1, LH2, HL2, HH2). Furthermore, processing performed by the frame decoding device in this embodiment is substantially similar to processing performed by the frame decoding device in the fifth embodiment, and therefore detailed description of processing of the frame decoding device in this embodiment is not presented.

As described above, in this embodiment, coded data corresponding to the group of the LL sub-band +  $\alpha$  (low frequency sub-bands subsequent thereto) is length-fixed, whereby coded data enabling practical multiple-speed  
5 decoding/playback (playback of the motion image at frame rates of 1 to n-fold speeds) to be performed easily can be provided.

[Ninth Embodiment]

In the coding device in the fifth embodiment, it has  
10 been described that image coded data has a data structure as shown in FIG. 8. In the case where the decoding end treats coded data in the order of this data structure, partially decoded data generated by partial decoding is of very low resolution (1/4 or 1/16 or 1/64). Considering that  
15 in this embodiment, for persons who do not desire a decoding form like this, a plurality of layers (layer 0 to N) as shown in FIG. 33 is defined, and coded data based on this data structure as shown in FIG. 34 is generated, thereby enabling hierarchical display according to a method in which the  
20 image size remains unchanged while image quality is gradually improved, as shown in FIG. 35.

And, this embodiment is characterized in that a various kinds of layers (layer 0, ..., N) in coded data having the above described layer structure are length-fixed so that  
25 they are equalized among respective frames.

<Frame Coding Device>

FIG. 43B

A block diagram showing the configuration of the frame coding device in this embodiment is shown in FIG. 45A. The frame coding device in this embodiment has replaced with a frame data coding unit E4501 the frame data coding unit A3607 in the coding device of the fifth embodiment shown in FIG. 36C. The reason why this replacement is applied is that while unit data in the fifth embodiment is the LL sub-band, unit data in this embodiment is corresponded to each layer. Operations in the designated image coded data code length inputting unit 102 are same as those in the fifth embodiment, and therefore detailed description thereof is not presented.

FIG. 43B shows in diagrammatic form the configuration of frame data coding unit in the frame coding device in this embodiment. In this figure, reference numerals 103, 104, 105, 4502, 3606 and 108 denote a frame data inputting unit, a frame data division unit 104, a voice data coding unit, an image data coding unit E, a frame coded data generation unit A and a frame coded data outputting unit, respectively. Furthermore, contents of processing in the frame data coding unit in this embodiment are similar to those in the frame data coding unit in the fifth embodiment except for the image data coding unit.

A block diagram showing the configuration of the image coding device in this embodiment is shown in FIG. 40. The coding device in this embodiment has replaced with a an image coded data generation unit H4001 the image coded data

generation unit D3605 constituting the image data coding unit A3601 in the fifth embodiment shown in FIG. 36B.

Except for this point, the image coding device and operations thereof in this embodiment are same as the image coding device and operations thereof in the fifth embodiment, and therefore detailed description thereof is not presented.

The image coded data generation unit H4001 forms image coded data into a layer structure to perform length fixation of layers. Description about the layer structure will be presented below.

As shown in FIG. 33, the image coded data generation unit H4001 collects entropy coded coding passes from a plurality of coding passes in a plurality of sub-bands before construct the layer. Furthermore, as shown in FIG. 47, when a coding pass is obtained from a certain coding block, the coding pass existing in the uppermost position of the coding passes is always selected.

In this layer structure, layers are generated in such a manner that they are length-fixed with the uppermost layer being generated first. That is, in FIG. 33, the layer 0 is first generated in such a manner that it is length-fixed, after which layers 1, 2, ... are generated. A flow through which one layer is generated will be described below, using FIG. 48 showing a flowchart.

First, a coding pass to be added to a layer to which attention is paid (attentional layer) is selected (S4701),



and the size of the code length (code length A) obtained  
as a result of adding the code length of the selected coding  
pass to the code length of the attentional layer is compared  
with the size of the target code length (S4702). If the  
5 code length A is smaller than the target code length, the  
selected coding pass is added to the attentional layer  
(S4703), and processing is returned back to S4701. If the  
code length A is not smaller than the target length, whether  
or not the two code lengths equal each other is examined  
10 (S4704). If the code length A equals the target length,  
the selected coding pass is added to the attentional layer  
(S4705) to end processing for constructing the attentional  
layer. If the code length A does not equal the target length  
and the code length A is larger than the target code length,  
15 the existence of other selectable coding passes is examined  
without selecting the selected coding pass (S4706). If  
there exists a selectable coding pass, processing is  
returned back to S4701. On the other hand, if there exists  
no selectable coding pass, dummy data is added to the  
20 attentional layer (S4707) to end processing.

In this embodiment, control is made so that at least  
coded data of the uppermost layer (layer 0) is length-fixed  
just as in the case of the second and fifth embodiments in  
which only the LL sub-band enabling the image of lowest  
25 image quality to be played back is length-fixed.

However, the present invention is limited thereto.  
For example, also for coded data representing not only the

uppermost layer but also several layers subsequent thereto,  
length fixation may be performed in a similar way. In this  
case, the optimum layer for which length fixation is  
performed is easily assigned to the multi-level quick  
5 playback speed, thus making it possible to play back an  
image of highest possible image quality during quick  
playback.

Furthermore, if the contents/bit arrangement of image  
data are analyzed, based on which the bit plane (coding  
10 pass) of the code block having bits as meaningful as  
possible is included in the upper layer, an image of very  
high image quality can be played back even in the case of  
quick playback.

#### <Frame Decoding Device>

15 The decoding device in this embodiment is shown in FIG.  
52. This device has the code length data fetching unit 2403  
and the quick decoding unit 2404 in the fifth embodiment  
replaced with a code length data fetching unit 5210 and a  
quick decoding unit 5292. The reason why these units are  
20 replaced is that while data treated with quick decoding is  
the LL sub-band in the fifth embodiment, data treated with  
quick decoding in this embodiment is the length-fixed layer.  
Furthermore, processing performed by the frame decoding  
device in this embodiment is substantially similar to  
25 processing performed by the frame decoding device in the  
fifth embodiment, and therefore detailed description of

09851559-051001



a plurality of sub-bands into a structure of a plurality of layers as in the case of the ninth embodiment and performs length fixation of coded data of each layer. That is, adaptation to stages of playback speeds of (the number of sub-bands or the number of sub-band groups)  $\times$  (the number of layers) is possible. That is, image playback of highest possible image quality suited to each playback speed can be performed.

It is described in the first place that the following method is used in this embodiment. Namely, image coded data is length-fixed for each sub-band, as described in the sixth embodiment. Furthermore, coded data among respective sub-bands have layer structures independent of one another. And, coded data representing these respective layers are length-fixed. Namely, if compared with the ninth embodiment, the layer structure of several stages as shown in FIG. 33 is created. In contrast to that, this embodiment is different from the ninth embodiment in that the layer structure of several stages is created independently for each sub-band/each sub-band group.

#### <Frame Coding Device>

A block diagram showing the configuration of the frame coding device in this embodiment is shown in FIG. 45A. The frame coding device in this embodiment has replaced with a frame data coding unit F4601 the frame data coding unit A3607 in the coding device in the fifth embodiment shown in FIG. 36C. The reason why this replacement is applied

is that while unit data is the LL sub-band in the fifth embodiment, unit data in this embodiment is changed to the layer in the sub-band. Operations in the designated image coded data code length inputting unit 102 are same as operations in the same processing unit in the fifth embodiment.

FIG. 43B shows in diagrammatic form the configuration of the frame data coding unit in the frame coding device in this embodiment. In this figure, reference numerals 103, 104, 105, 4602, 3606 and 108 denote a frame data inputting unit, a frame data division unit, a voice data coding unit, an image data coding unit F, a frame coded data generation unit A and a frame coded data outputting unit, respectively. Contents of processing in the frame data coding unit in this embodiment are similar to those in the frame data coding unit in the fifth embodiment except for the image data coding unit.

A block diagram showing the configuration of the image coding device in this embodiment is shown in FIG. 41. In the image coding device of this embodiment, the image coded data generation unit D3605 constituting the image data coding unit A3601 of the fifth embodiment shown in FIG. 36B is replaced with an image coded data generation unit I4101. Except for this point, the image coding device and operations thereof in this embodiment are same as the image coding device and operations thereof in the fifth embodiment.

In the image coded data generation unit I4101, length fixation of the coded data of each sub-band is performed as described first in the sixth embodiment.

Thereafter, as shown in FIG. 31, the coded data is  
5 formed into a layer structure in which each sub-band is comprised of two layers, and coded data for each layer is length-fixed. Furthermore, the number of layers of each sub-band is considered as 2 in FIG. 31 to avoid complicated explanation, but the present invention is not limited  
10 thereto. As a matter of course, if the number of layers is increased to 3 or more, coded data of structure with very numerous hierarchies can be created.

#### <Frame Decoding Device>

The decoding device in this embodiment is shown in FIG.  
15 53. This device has the fixed length data fetching unit 2403 and the quick decoding unit 2404 in the fifth embodiment replaced with a fixed length data fetching unit 5301 and a quick decoding unit 5302. The reason why these units are replaced is that while data treated with quick  
20 decoding is the LL sub-band in the fifth embodiment, data treated with quick decoding in this embodiment is the layer length-fixed in each sub-band. Furthermore, processing performed by the frame decoding device in this embodiment is substantially similar to processing performed by the  
25 frame decoding device in the fifth embodiment, and therefore detailed description of processing in terms of

the frame decoding device in this embodiment is not presented.

As described above, length fixation is performed also in the sub-band, and coded data of each layer constituting the each sub-band is also length-fixed, whereby image coded data adaptable to quick playback of multi-level speeds (playback of the motion image at multi-level frame rates) can be provided. Also, this image coded data can be decoded/played back efficiently.

10 (Modification)

In the above described embodiments, it has been described that a part or all of coded data of the coded data of two or more of sub-bands or layer structures are length-fixed, and that the length-fixed coded data is effective for using quick (multiple-speed) playback.

However, the method of creating coded data of the present invention may be used for aspects other than quick playback, such a form is also included in the scope of the present invention. For example, since data processing is easily performed separately in parallel for each sub-band/layer if coded data of each sub-band or layer is length-fixed, decoding processing and error correction may be performed for the coded data of each sub-band and each layer as long as technically possible, which is included in the scope of the present invention.

Furthermore, the present invention may be applied either as a part of a system comprised of a plurality of

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apparatuses (for example, a host computer, an interface apparatus, a reader, a printer, etc.) or as a part of equipment comprised of a single apparatus (for example, a digital video camera, digital still camera).

5       Also, the present invention should not be limited to devices and methods for achieving the above described embodiments, but cases where the program code of software to achieve the above described embodiments is supplied to the computer in the above described system or equipment (CPU  
10 or MPU), the computer of the above described system or equipment operates the above described various kinds of devices in accordance with this program code, thereby achieving the above described embodiments are also included in the scope of the present invention.

15       Also, in this case, the program code related to the above described software itself achieves the features of the above described embodiments, and the program code itself and means for supplying the program code to the computer, specifically a storage medium storing therein the  
20 above described program code are included in the scope of the present invention.

As for such a storage medium storing therein the program code, for example, a floppy disk, a hard disk, an optical memory disk, a magneto-optical disk, a CD-ROM, a  
25 magnetic tape, a nonvolatile memory card, a ROM or the like may be used.



Furthermore, not only when the above described computer controls various kinds of devices in accordance with only the supplied program code, whereby the features of the above described embodiments are achieved, but also  
5 when the above described program code operates in collaboration with the OS (operating system) operating on the computer, other application software or the like to achieve the above described embodiments, the program code is included in the scope of the present invention.

10 Furthermore, the cases where after this supplied program code is stored in a memory provided for the feature expansion board of the computer or the feature expansion unit connected to the computer, the CPU or the like provided for the feature expansion board or the feature expansion  
15 unit performs a part or all of actual processing based on instructions of the program code, and the above described embodiments are achieved by the processing are also included in the scope of the present invention.

Furthermore, in the case of applying the present  
20 invention to the above described storage medium, the program code corresponding to the previously described flowcharts (shown in FIGS. 14, 15 and 16), or the flowchart in the second embodiment, or the flowchart in the third embodiment, or the flowchart shown in FIG. 18 in the fourth  
25 embodiment is stored in the storage medium.

As described above, according to the present invention, in states in which hierarchical coding can be performed,

09851559-051001

technologies for generating coded data that can cope with many kinds of decoding/playback speeds/times or technologies for decoding these coded data in accordance with many kinds of decoding/playback speeds/times can be  
5 provided.

The present invention is not limited to the above embodiments and various changes and modifications can be made within the spirit and scope of the present invention. Therefore, to appraise the public of the scope of the  
10 present invention, the following claims are made.

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